

## APPENDIX

## TRAPPED PARTICLE FLUX MODELS AT NSSDC/WDC-A-R&amp;S

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## Abstract

This is a document prepared for the NASA/SDIO Workshop on Space Environment Effects on Materials at Langley Research Center June 28-30, 1988. It summarizes our perception of what data are needed in the future for trapped particle modeling. We have also include a short summary of NSSDC's past and future modeling activities and a list of satellite data that have not yet been considered in the modeling efforts.

## Introduction

This paper addresses the following questions:

- I. What is the present status of NSSDC's models ?
- II. Which data have become available since the last model up-date?
- III. What is needed to improve the models ?
- IV. What are NSSDC's future modeling activities ?

The answers are as follows:

## Present Status of NSSDC's Models

NSSDC's trapped particle models describe the omnidirectional proton and electron fluxes in the inner and outer radiation belts in terms of energy, L-shell, and B/B<sub>0</sub>.

|           | Name | Energy Range  | L range  | NSSDC Report |
|-----------|------|---------------|----------|--------------|
| Electrons | AE-8 | 0.04 - 7 MeV  | 1.2 - 11 | Appendix     |
| Protons   | AP-8 | 0.1 - 400 MeV | 1.17-7   | ref. 2)      |

AE-8 and AP-8 are the latest editions in a series of models that have been developed and continuously improved by J. I. Vette and his collaborators at NSSDC/WDC-A-R&S over the last decades. This is documented in several NSSDC reports and is summarized in ref.1 (Table 1) and the Appendix. For each species two model maps have been established, one for solar minimum conditions (epoch 1964) and one for solar maximum conditions (epoch 1970). The models are based on satellite data up to 1977 (see Figures 3,4,5 and 6 in ref. 1); this includes 27 satellites over a time span of almost 20 years. The data coverage in B/B<sub>0</sub> - L space is shown in Figures 1 and 2 of ref.1. The models provide time averages over half a year or more. The average enhancement due to magnetic storms during this period is included.

## Data Available Since the Last Model Up-date

### Low-altitude, circular orbits:

Space Shuttle, NASA, 250 to 450 km, 20 to 60 deg., several flights since 1981

Dosimeters at several locations on the shuttle and on the astronauts determined the accumulated dose per shuttle flight.

Trapped Ions in Space Experiment, J.H. Adams, NRL; shuttle flight: Oct 84, 245 km, 57 deg.

The stack of plastic track detectors allowed measurements of He/p ratio in the energy range 7 to 70 MeV/amu.

Long Duration Exposure Facility, R. Gualdoni, NASA HQ.

The free-flying LDEF module was released from the shuttle on 4/6/84 and will be recovered when shuttle flights resume; contains passive track detectors of F.J. Rich, AFGL (protons) and of J.H. Adams, NRL (heavy ions).

### Circular, polar orbits:

DMSP, USAF, 840 km, 7 satellites since 1976

Silicon Dosimeter, J.B. Blake, Aerospace Corp.

4 detectors allow separation of electron and proton fluxes with different threshold energies.

TIROS & NOAA, NOAA, 850 km, 4 satellites since 1978,

Space Environment Monitor, D.J. Williams, NOAA

protons, 5 energy bands above 30 KeV

electrons, 3 energy bands above 30 KeV

### Geostationary orbits:

SMS & GOES, NOAA, 6.67 Re, 8 satellites since July 1974, two satellites operate simultaneously at 75 and 135 west.

Energetic Particle Monitor, D.L. Williams, NOAA

solid state detector, protons from 0.8 to 500 MeV,

alpha particles from 4 to 392 MeV, electrons > 2 MeV.

Higbie, DOD, 6 satellites since 1976

Energetic Particle Detector, P.R. Higbie, Los Alamos

electrons from 0.03 to 2 MeV

protons from 0.05 to 150 MeV

alpha particles from 1.2 to 600 MeV (special mode)

### Highly elliptical orbits:

S3-3, USAF, 246 - 7856 km, 97.5 deg., launched 7/8/76

Energetic Electron Spectrometer, A.L. Vampola, Aerospace Corp.

electrons from 0.0012 to 1.6 MeV

protons from 0.08 to 3 MeV, alpha > 4 MeV

ISEE-1,-2, NASA/ESA, 281 - 138120 km, 29 deg., 10/22/77

Medium Energy Particle Experiment, Williams, NOAA

electrons from 20 KeV to 1 MeV

protons from 0.02 to 1.2 MeV

SCATHA, DOD, 184 - 43905 km, 27 deg., 1/30/79

Energetic Proton Detector, J.B. Blake, Aerospace Corp.

protons from 0.02 to 2 MeV

Rapid Scan Particle Detector, D.A. Hardy, AFGL  
 electrons from 50 eV to 1.1 MeV  
 ions from 50 eV to 35 MeV  
 High-Energy Particle Detector, J.B. Reagan, Lockheed  
 electrons from 0.3 to 2.1 MeV  
 protons from 1 to 100 MeV  
 alpha particles from 6 to 60 MeV  
 AMPTE/CCE, NASA, 550 - 49400 km, 5 deg., 8/16/84  
 Medium Energy Particle Analyzer, R.W. McEntire, APL  
 composition and spectra from 10 KeV/n to 6 MeV/n  
 32 sector angular resolution.  
 AMPTE/IRM, FRG, 550 - 112800 km, 29 deg., 8/16/84  
 Suprathermal Ionic Charge Analyzer, D.K. Hovestadt, MPIE  
 10 to 300 KeV/q; electron sensor: 35 to 220 KeV

#### High-altitude orbits:

NTS-2, NRL, 11000 n. miles, 63 deg., launched 7/17/77  
 DMSP-type dosimeter, A.I. Cole, TRW Systems  
 IUE, ESA/NASA, 26643 - 44951 km, 29 deg., 1/26/78  
 Silicon detector, electrons > 1.3 MeV, protons > 15 MeV

### Requirements for Model Improvement

The last page of ref. 1 is a modeler's wish list. Most of these 10-year old recommendations will be fulfilled with the long awaited CRRES satellite. Modeling needs a reliable data base large enough to allow the necessary statistical evaluation. Therefore it is important to insure (i) a long CRRES mission time, (ii) the resources to process all acquired raw data, (iii) follow-up satellite missions similar to CRRES. It would be also desirable to obtain direct flux measurements at shuttle/space station altitudes.

### NSSDC's Future Modeling Activities

- completion of NSSDC report describing AE-8
- comparisons with some of the measurements listed in ref. 2.

The development of dynamic models can be envisaged for the time after the successful completion of the CRRES satellite mission.

### References

1. Vette, J. I., K. W. Chan, and M. J. Teague, Problems in Modeling the Earth's Trapped Radiation Environment, Air Force Geophysics Lab report AFGL-TR-78-0130, Hanscom AFB, MA, 1978.
2. Short summary of AE-8 model; enclosed
3. D.M. Sawyer and J.I. Vette, AP-8 Trapped Proton Environment, NSSDC/WDC-A-R&S Report 76-06, 175 pages (1976).

## Appendix: AE-8 Short Summary

The AE-8 (MAX and MIN) models were established from earlier AE models with some modifications (as indicated below).

| Region                      | Solar Activity            | Model | NSSDC Rep. | Modification   |
|-----------------------------|---------------------------|-------|------------|--|
| Outer zone<br>( $L > 2.8$ ) | Solar minimum and maximum | AE-4  | 72-06      | Energy spectra above 2 MeV increased based on ATS-6, AZUR, and OV1-19 data. B-cutoff based on AZUR data. |
| Inner zone<br>( $L < 2.4$ ) | Solar minimum             | AE-5  | 74-03      | None   |
|                             | Solar maximum             | AE-6  | 76-04      | None   |

An interpolation procedure was applied between  $L=2.4$  and  $L=2.8$  to obtain smooth transitions between the inner and outer zones at all energies. In comparison with earlier AE models you will find:

- somewhat lower fluxes at low altitudes ( $< 300$  km)
- small modifications in the range  $L=2.5$  to  $L=2.7$
- the spectrum above 2 MeV in the outer zone is harder than AE-4